



CENTRAL CALIFORNIA AIR QUALITY RESEARCH

Evolving Science in Central California

Why do we need air quality studies?

John G. Watson (johnw@dri.edu)

Desert Research Institute
University of Nevada

Philip M. Roth

Envair
San Anselmo, CA

Objectives

- Review what we've learned from 30 years of central California air quality studies
- Identify contributions from these studies to the advancement of air quality science
- Provide some perspective on how to extract the greatest value from central California air quality experiments
- Specify some of the scientific issues that need to be addressed in the future

Steps in the scientific method

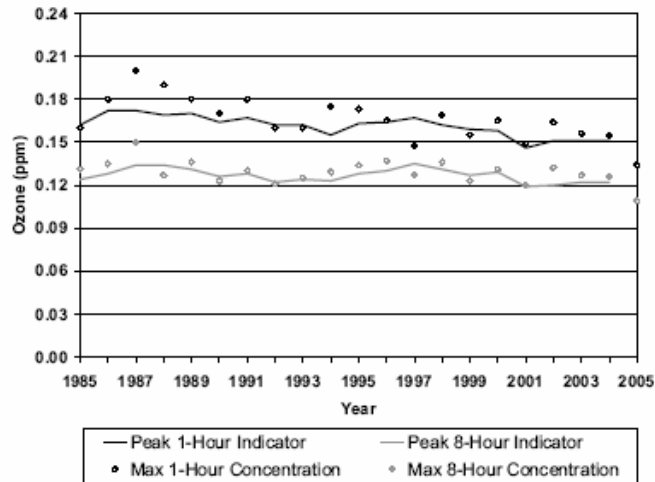
1. Identify and quantify the problem
2. Formulate hypotheses about the causes of the problem
3. Design and conduct experiments to test hypotheses
4. Evaluate effectiveness of emission reduction measures
5. Implement control strategies to reduce the problem
6. Measure changes to evaluate the effectiveness of strategies
7. Go to step 1

Limitations of the method for air quality studies

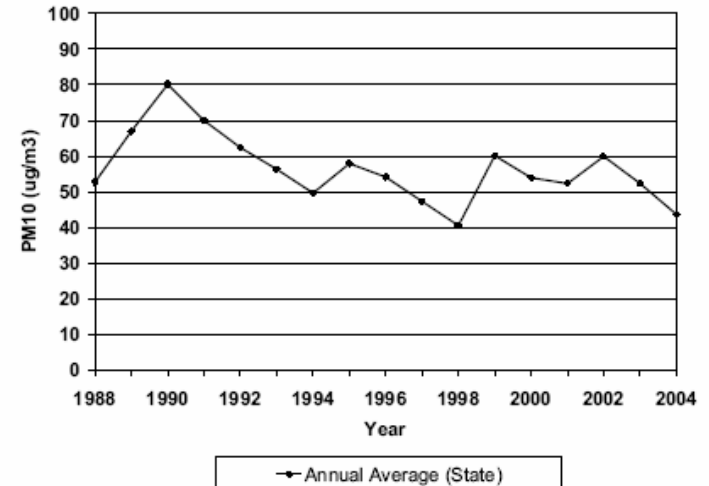
- Measurement and modeling technology is limited, but continually improving
- Environmental data is inherently noisy and uncertain
- Hypotheses are based on pre-conceived notions
- Atmospheric processes are nonlinear
- Control strategies have unintended consequences
- Real-world emissions differ from estimates
- Study resource requirements are high

Problem: O₃, PM₁₀ and PM_{2.5} are too high

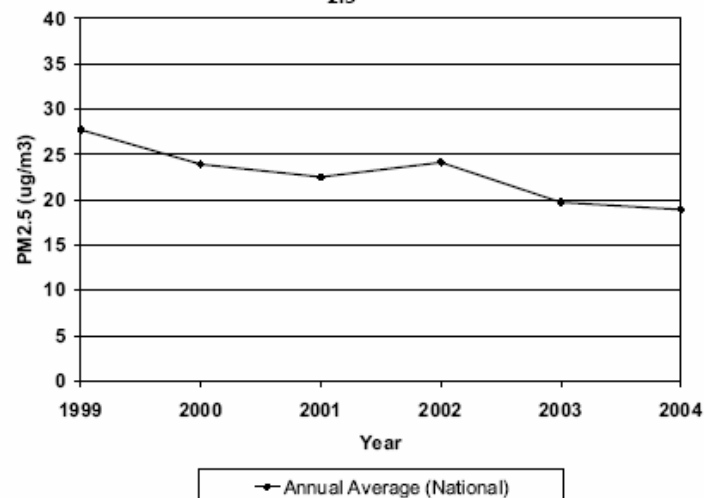
San Joaquin Valley Air Basin
Ozone Trend



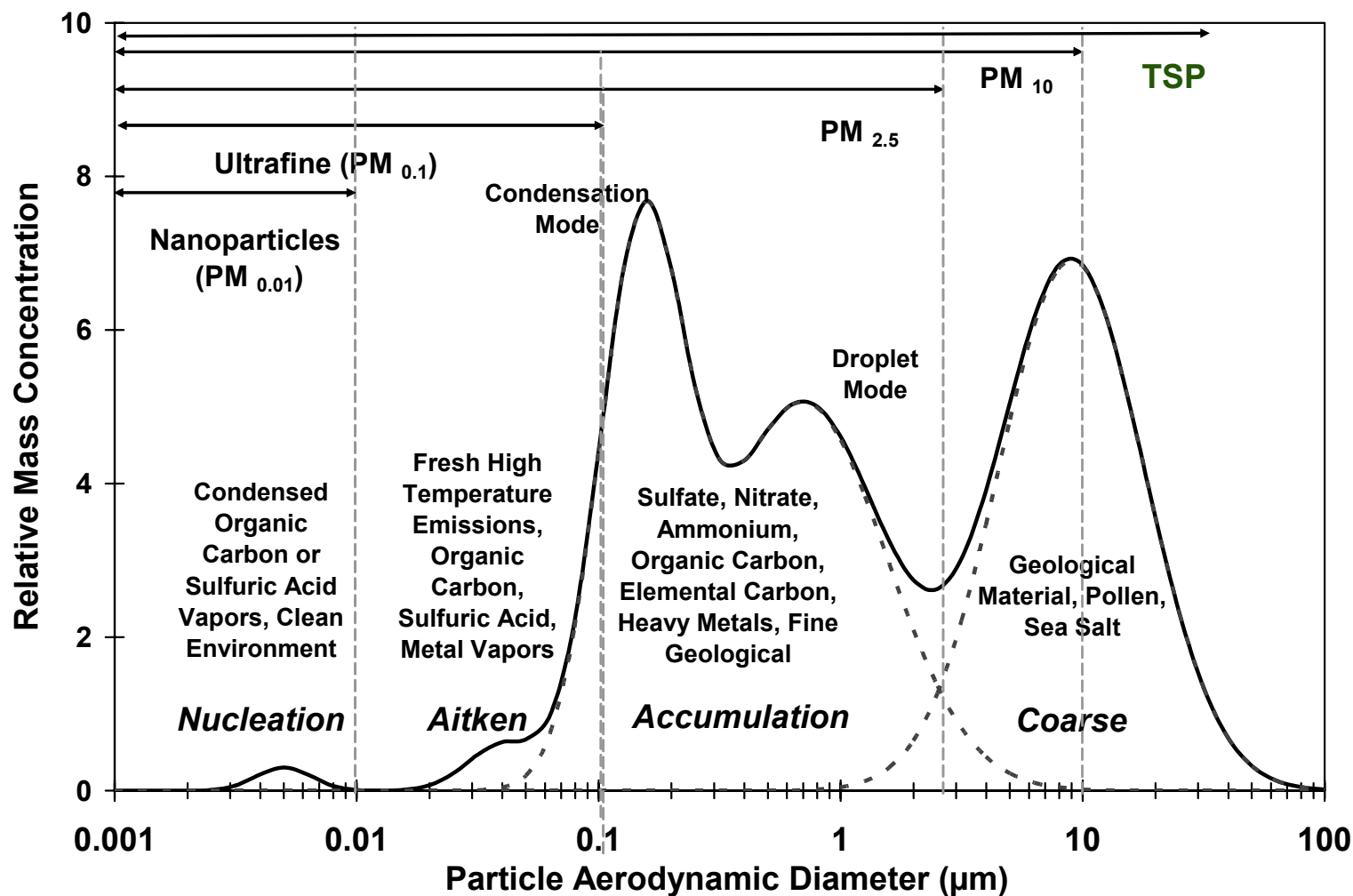
San Joaquin Valley Air Basin
PM₁₀ Trend



San Joaquin Valley Air Basin
PM_{2.5} Trend



What are PM₁₀ and PM_{2.5}?



Major field studies

- 1970: Project Lo-Jet (identified summertime low-level jet and Fresno eddy)
- 1972: Aerosol Characterization Experiment (ACHEX, first TSP chemical composition and size distributions)
- 1979-1980: Inhalable Particulate Network (first long-term PM_{2.5} and PM₁₅ mass and elemental measurements in Bay Area, Five Points)
- 1978: Central California Aerosol and Meteorological Study (seasonal TSP elemental composition, seasonal transport patterns)
- 1979-1982: Westside Operators (first TSP sulfate and nitrate compositions in western Kern County)
- 1984: Southern SJV ozone study (first major characterization of O₃ and meteorology in Kern County)
- 1986-1988: California Source Characterization Study (quantified chemical composition of source emissions)
- 1988-89: Valley Air Quality Study (first spatially diverse, chemical characterized, annual and 24-hour PM_{2.5} and PM₁₀ seasonal)
- Summer 1990: San Joaquin Valley Air Quality Study/Atmospheric Utilities Signatures Predictions and Experiments (SJVAQS/AUSPEX, first central California regional study of O₃ and PM_{2.5})
- Winter 1995: CRPAQS Pilot Study (IMS95, first sub-regional winter study)
- December 1999 to February 2001: CRPAQS and CCOS (first year-long, regional-scale effort)
- December 1999 to present: Fresno Supersite (first multi-year experiment with advanced monitoring technology)

Inhalable Particulate Network 1979-80

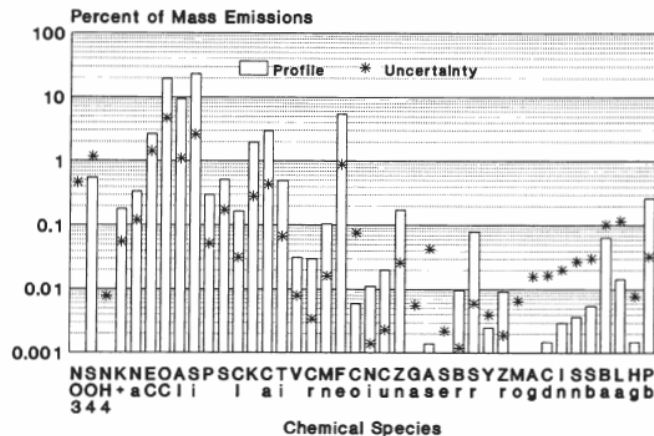
measured high concentrations

TABLE 5.3.1
RANGES OF TSP, IP AND FP
ANNUAL ARITHMETIC AVERAGE AND MAXIMUM CONCENTRATIONS
BETWEEN SITES WITHIN URBAN AREAS

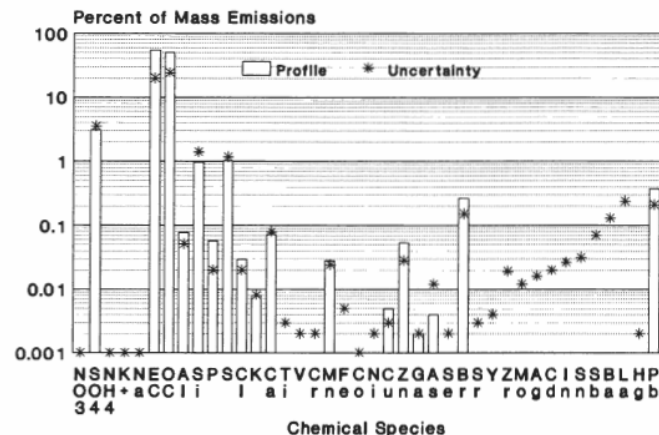
<u>Urban Area</u>	<u>No. of Sites</u>	<u>TSP, ug/m³</u>		<u>IP, ug/m³</u>		<u>FP, ug/m³</u>	
		<u>Average</u>	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>
Birmingham	4	63 to 114	120 to 313	30 to 58	75 to 140	19 to 32	37 to 52
San Francisco	3	49 to 79	103 to 269	25 to 35	81 to 113	13 to 18	60 to 82
Buffalo	2	87 to 98	165 to 191	52 to 63	111 to 134	27 to 33	58 to 70
Los Angeles	2	73 to 161	146 to 392	46 to 92	99 to 200	25 to 37	72 to 109
Philadelphia	2	49 to 57	137 to 161	37 to 48	134 to 146	23 to 32	99 to 112
Minneapolis	2	51 to 76	126 to 221	30 to 42	61 to 105	14 to 17	44 to 47
All Sites	19	39 to 161	90 to 392	24 to 92	58 to 200	13 to 37	44 to 112

Source characterization studies (1986-88) provided “fingerprints” for different emitters

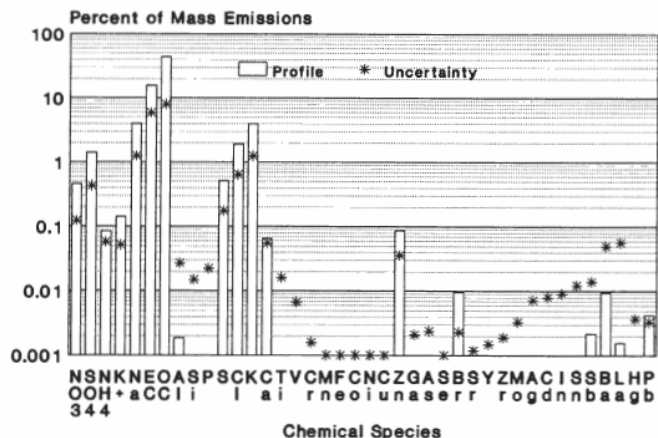
Fresno Paved Road
SOIL: PM10



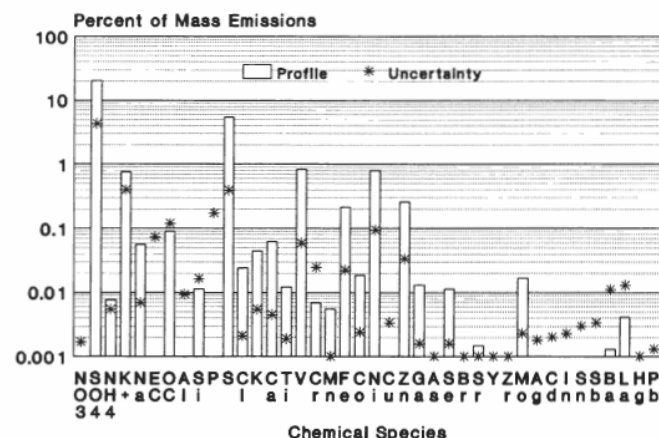
Motor Vehicle
MOVES2: PM2.5



Vegetative Burning, Bakersfield Cordwood
Majestic Fireplace: PM2.5

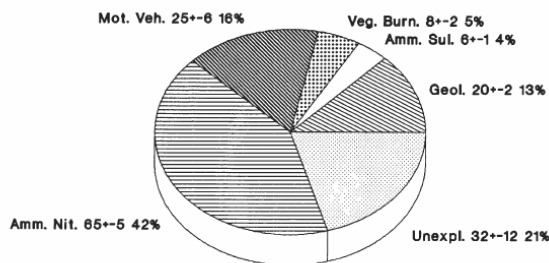


Crude Oil Combustion
Santa Fe Crude Boiler: PM2.5



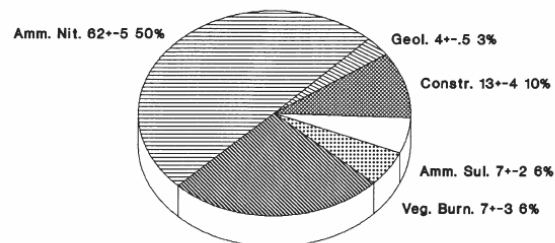
VAQS (1988-89) revealed large contributions from ammonium nitrate during winter and crude oil combustion in Kern county

SOURCE CONTRIBUTIONS TO 24-HOUR PM10
12/11/88 at Stockton



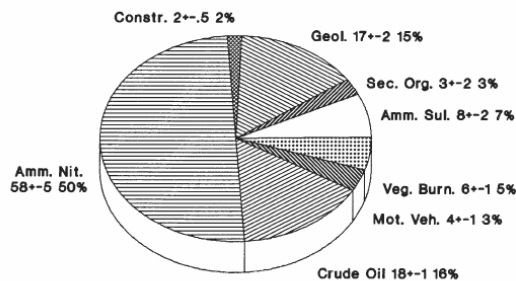
Calc./Meas. PM10: 132+-9/166+-8 ug/m3

SOURCE CONTRIBUTIONS TO 24-HOUR PM10
12/11/88 at Fresno



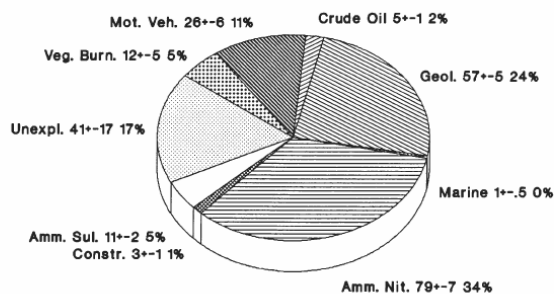
Calc./Meas. PM10: 113+-10/90+-5

SOURCE CONTRIBUTIONS TO 24-HOUR PM10
12/11/88 at Fellows



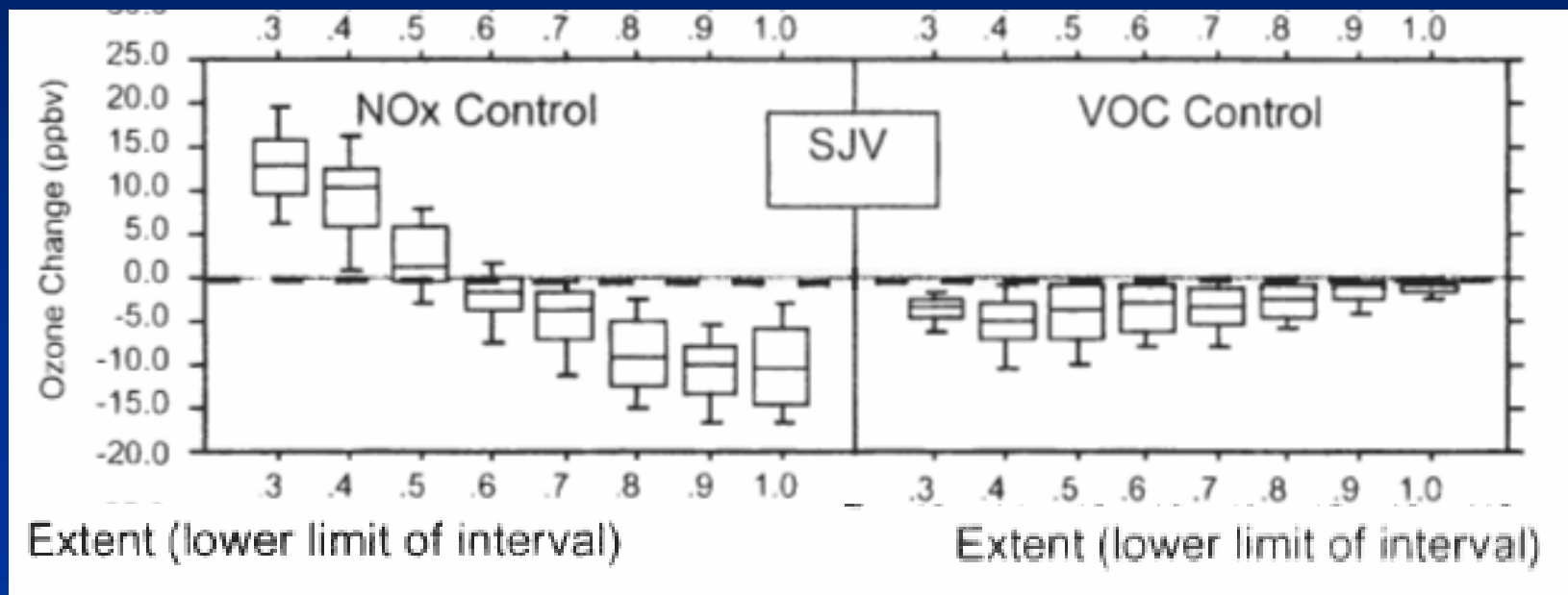
Calc./Meas. PM10: 126+-6/120+-6

SOURCE CONTRIBUTIONS TO 24-HOUR PM10
12/11/88 at Bakersfield

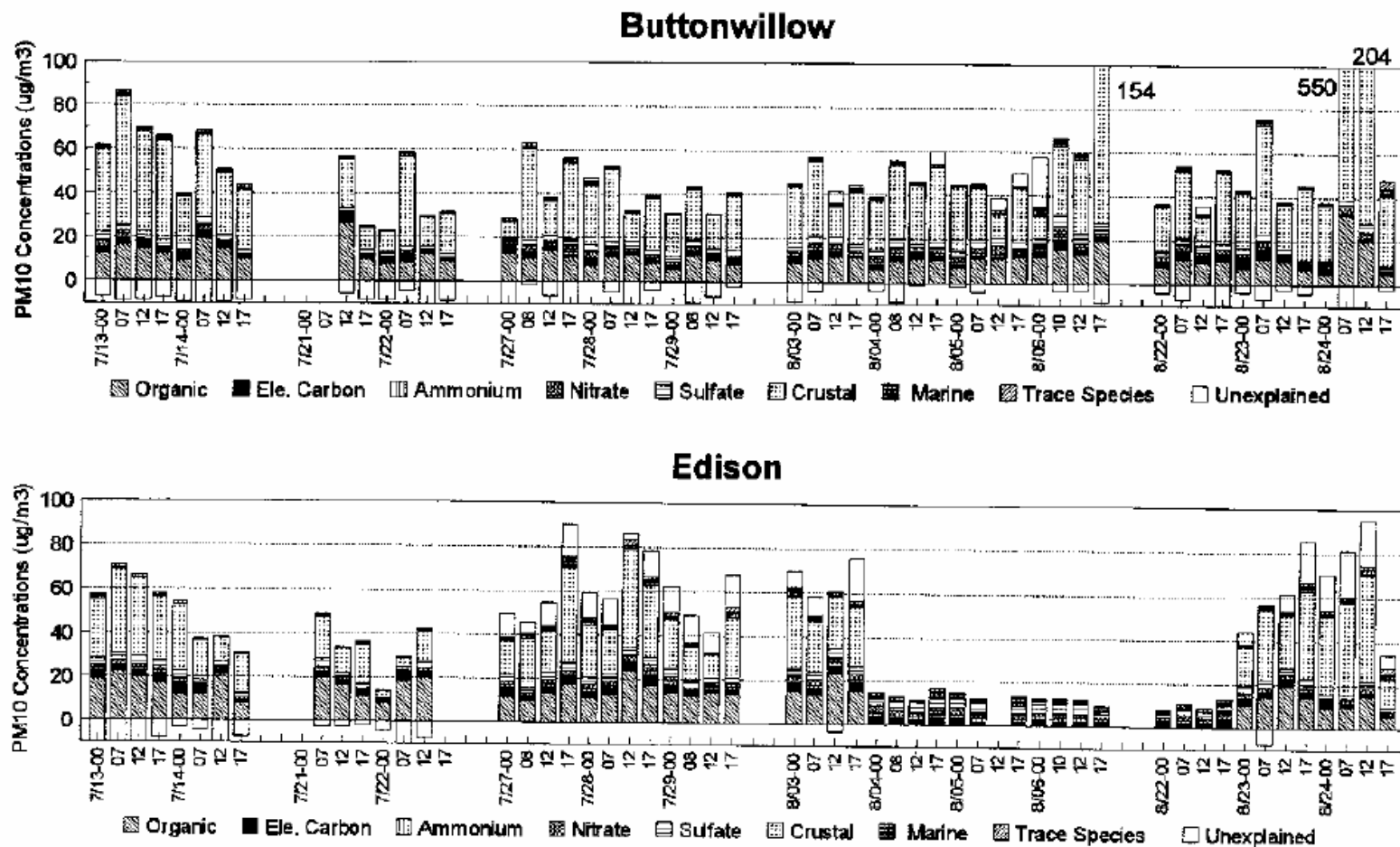


Calc./Meas. PM10: 194+-12/235+-12

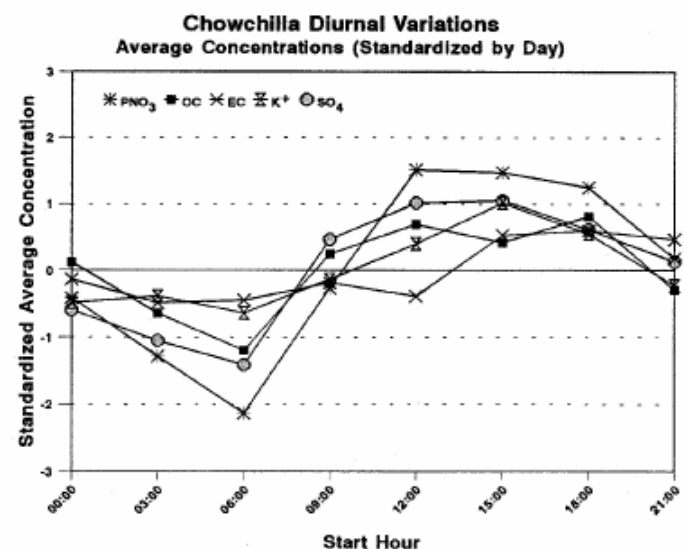
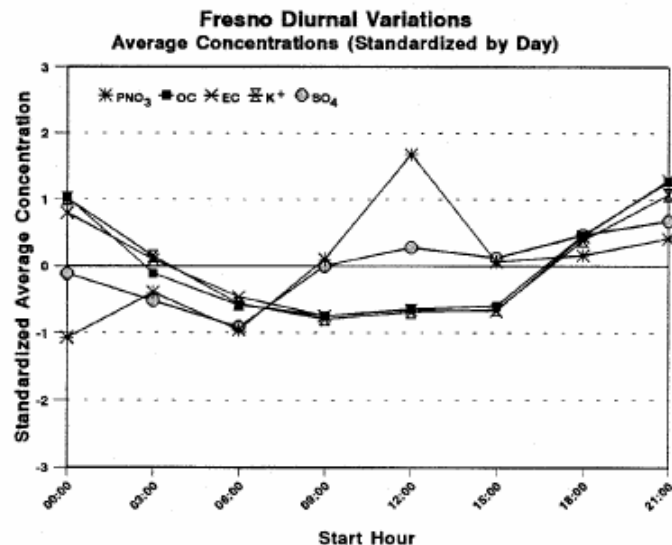
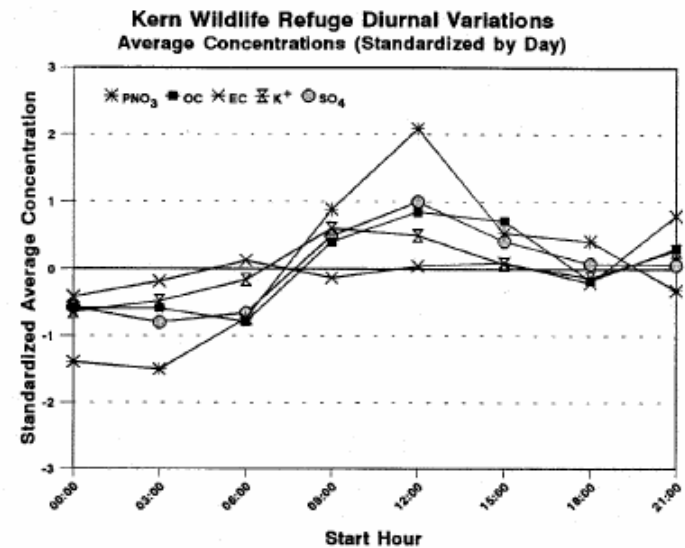
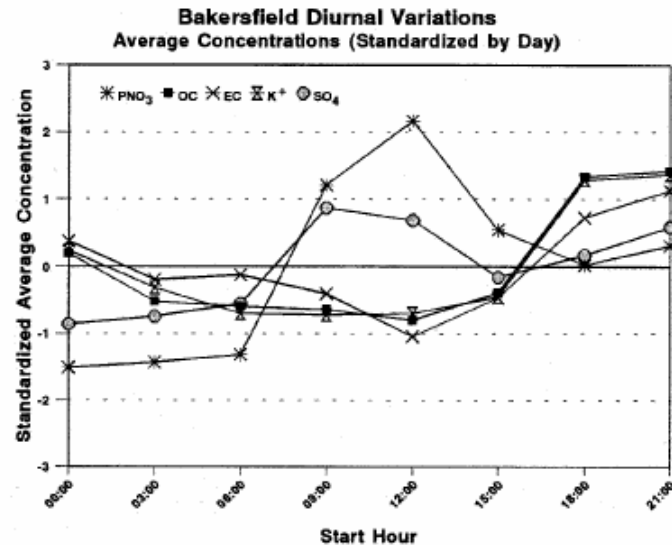
SJVAQS/AUSPEX (1990) showed where and when NO_x or VOC reductions would reduce O₃



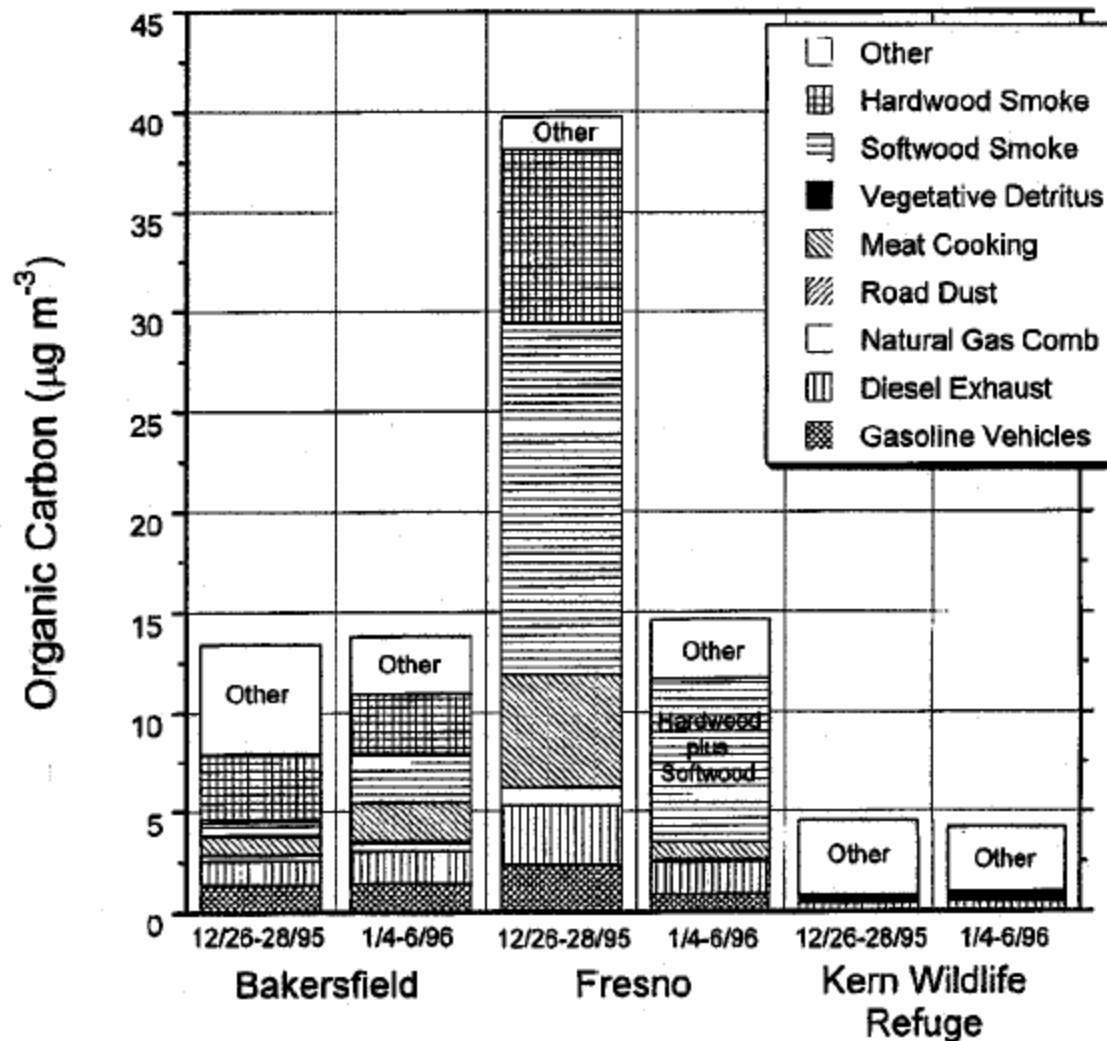
SJVAQS/AUSPEX (1990) showed summertime diurnal variations with high ozone



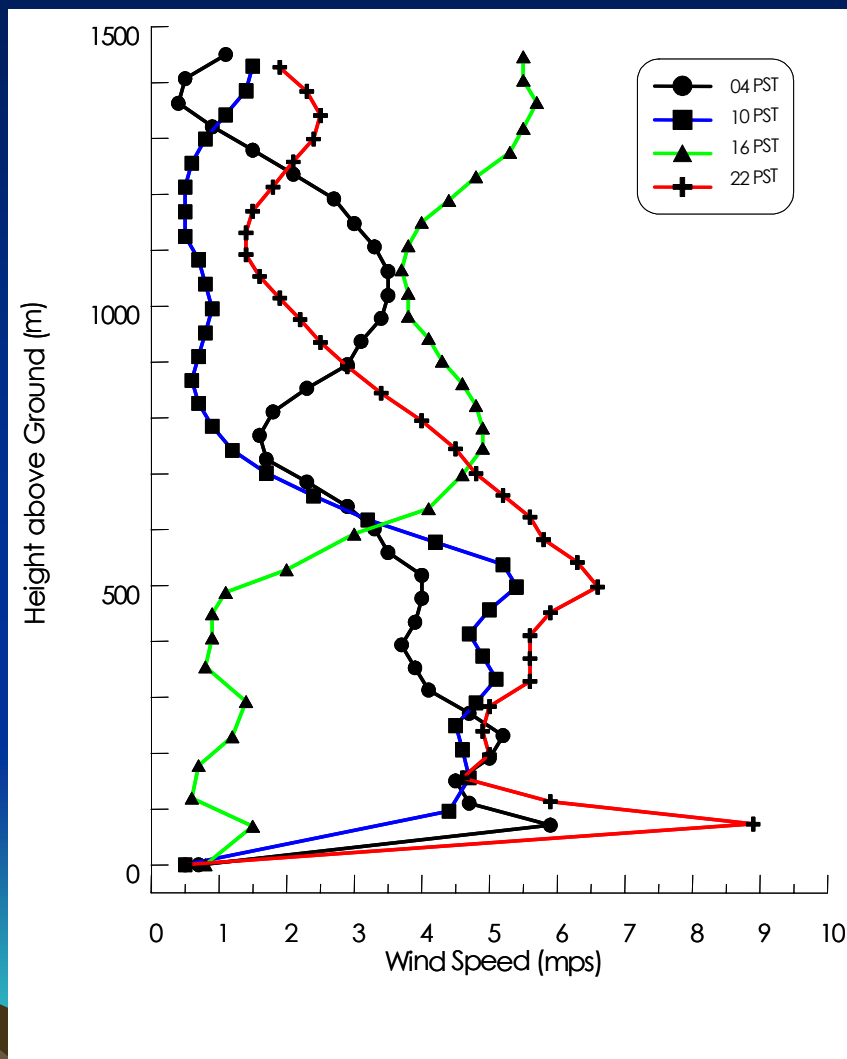
CRPAQS Pilot Study (IMS95, Winter 1995) showed wintertime diurnal distribution



CRPAQS Pilot Study (IMS95, Winter 1995) showed cooking as well as wood burning contributions

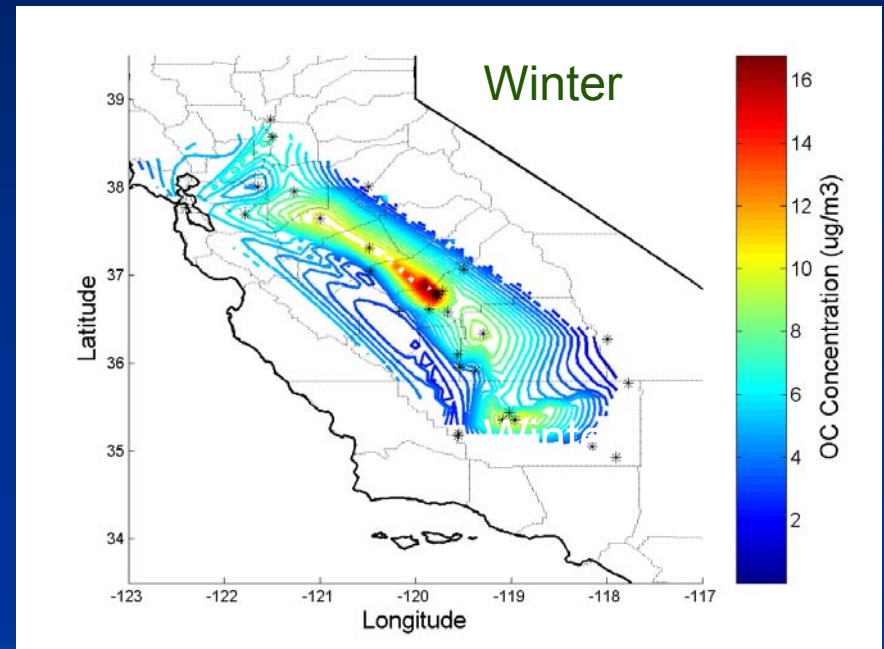
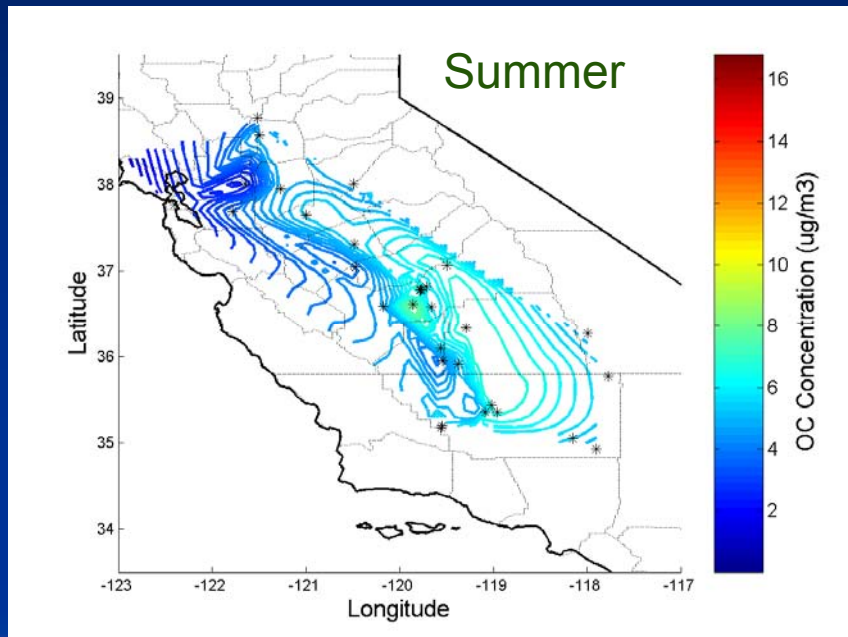


CRPAQS Pilot Study (IMS95, Winter 1995) showed higher wind speeds above a shallow surface layer



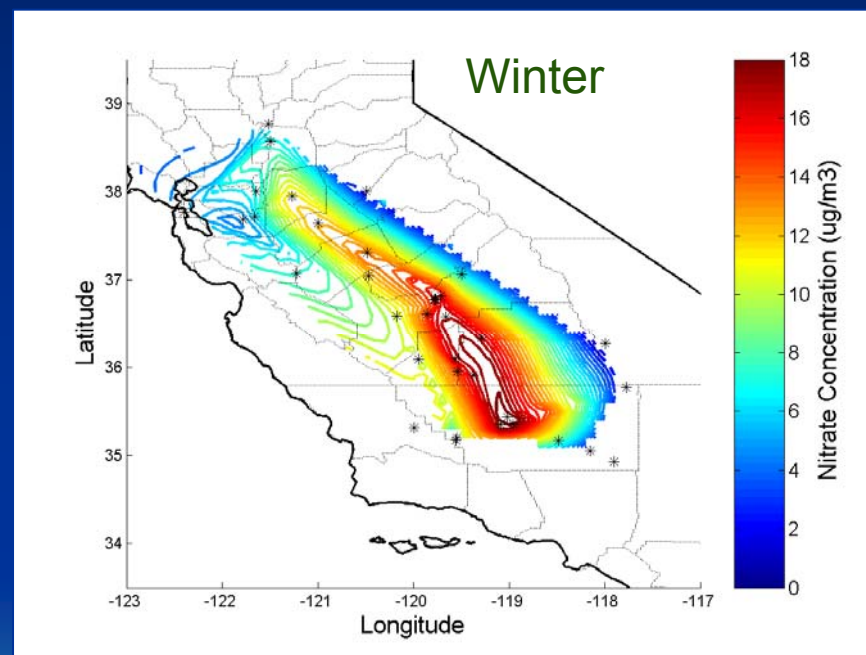
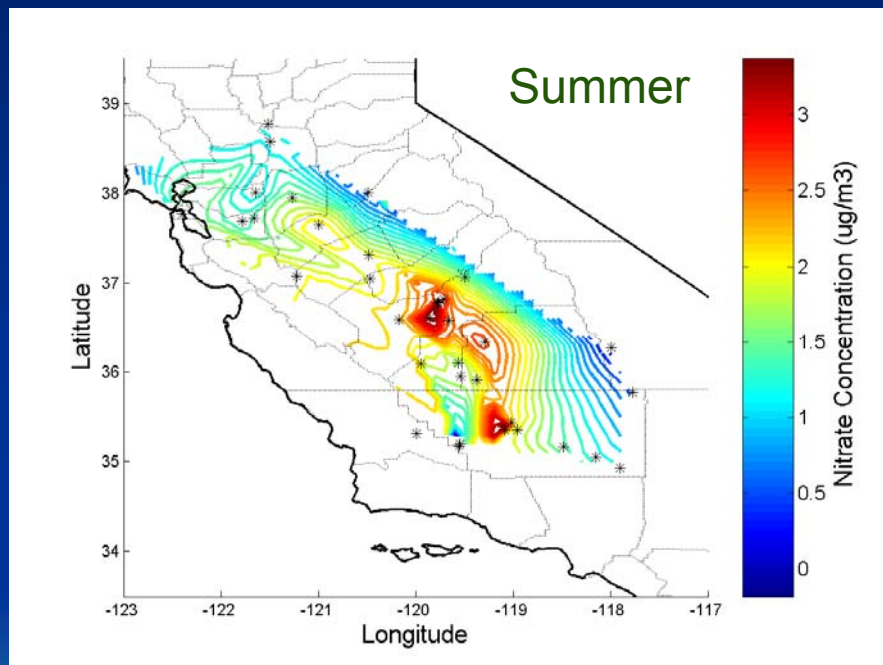
CRPAQS Findings

Dense sampling network showed that carbon was highest in cities during winter



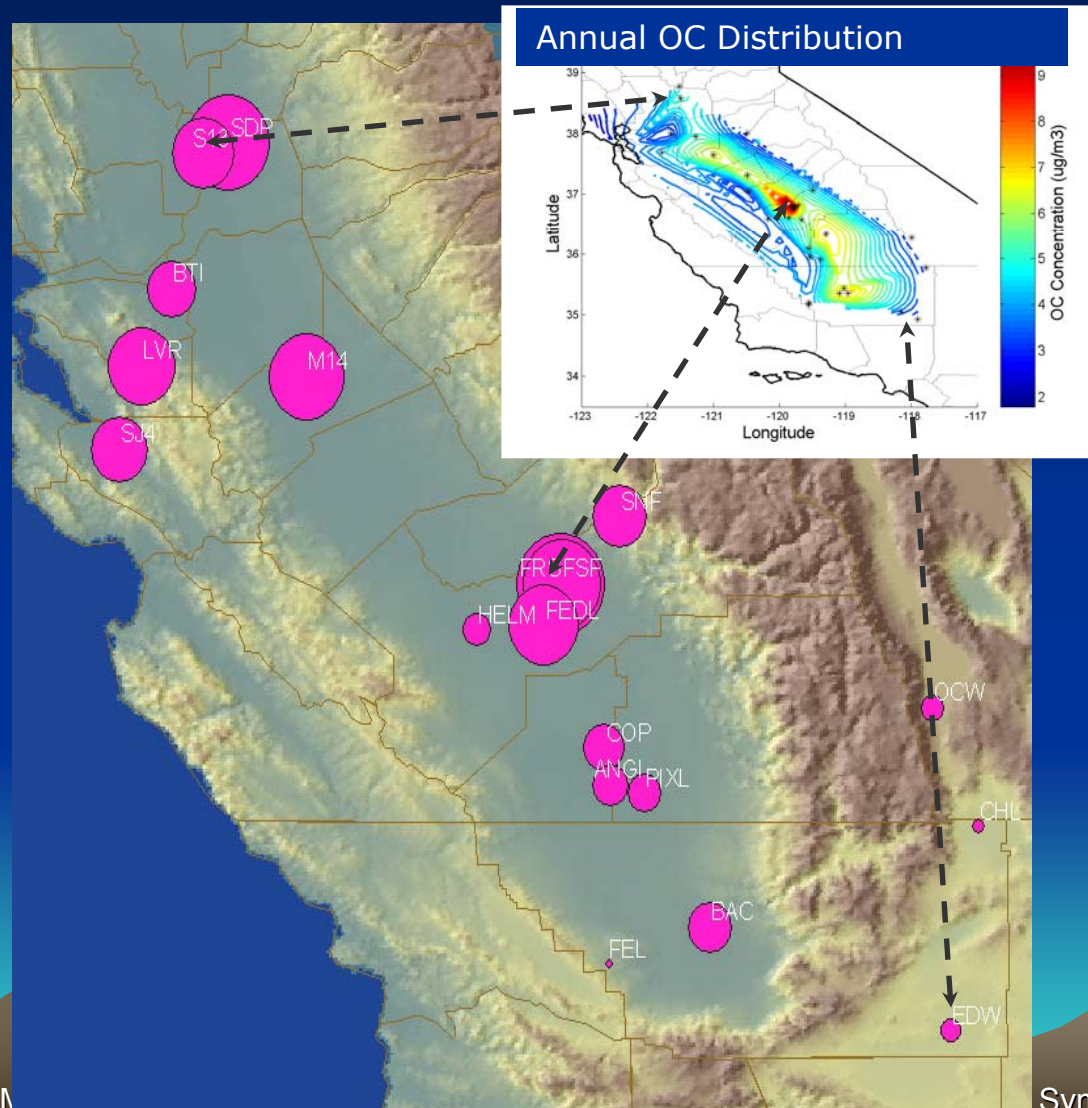
CRPAQS Findings

Dense sampling network showed that nitrate was high in all of SJV during winter



CRPAQS Findings

Wood smoke markers were highest in cities



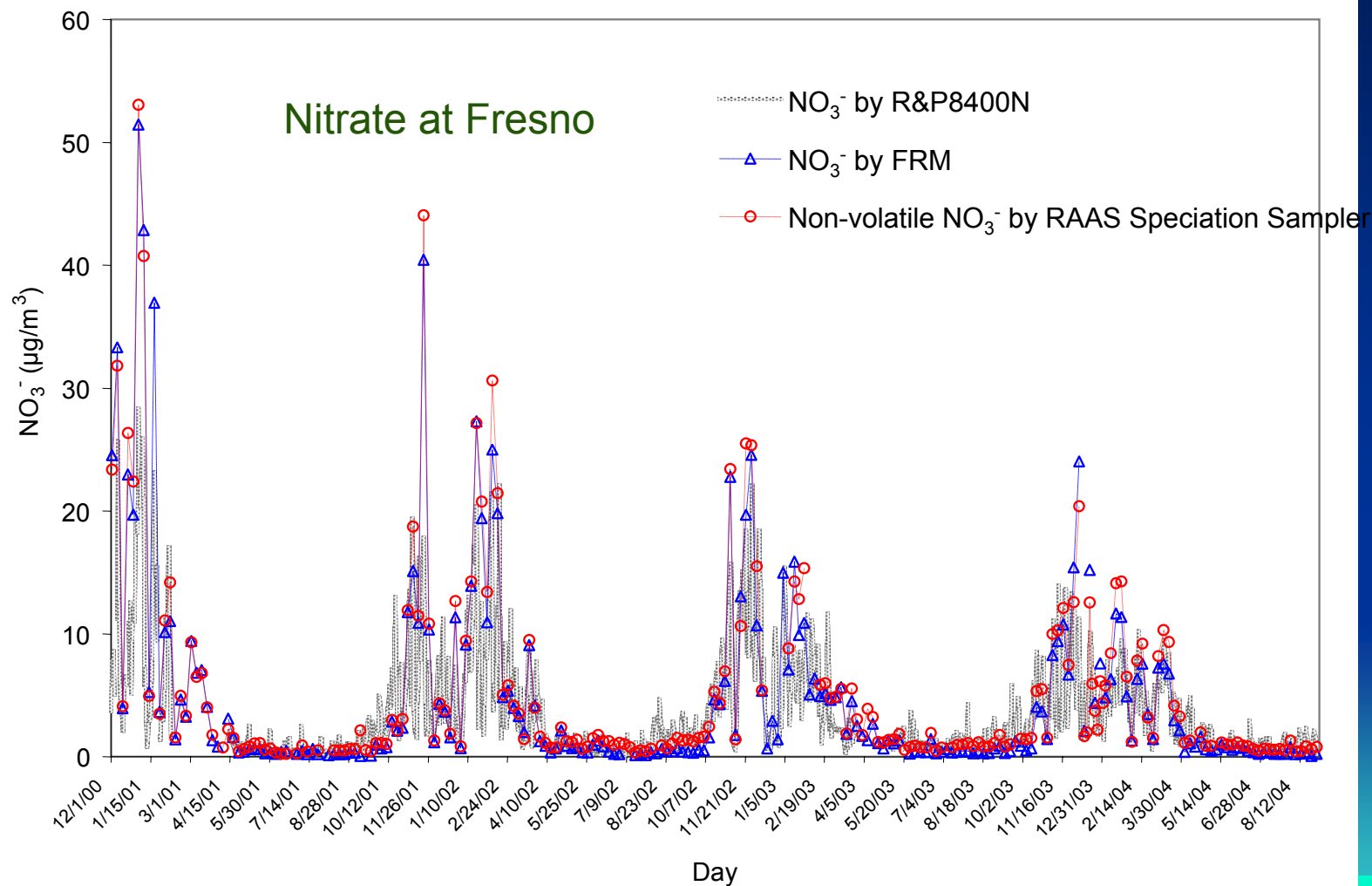
Levoglucosan Concentrations (ng/m3)		
	Annual Avg	Winter Avg*
FEL	6	26
CHL	7	32
YOSE	9	38
EDW	12	52
OCW	14	58
HELM	19	81
PIXL	19	82
ANGI	23	98
COP	32	138
BAC	49	209
BTI	50	215
SNF	57	244
SJ4	58	247
S13	63	269
LVR	68	291
FEDL	75	323
M14	101	433
FRS	121	521
SDP	128	551
FSF	202	868

* Predicted concentration based on mass concentration measurements

CRPAQS Findings

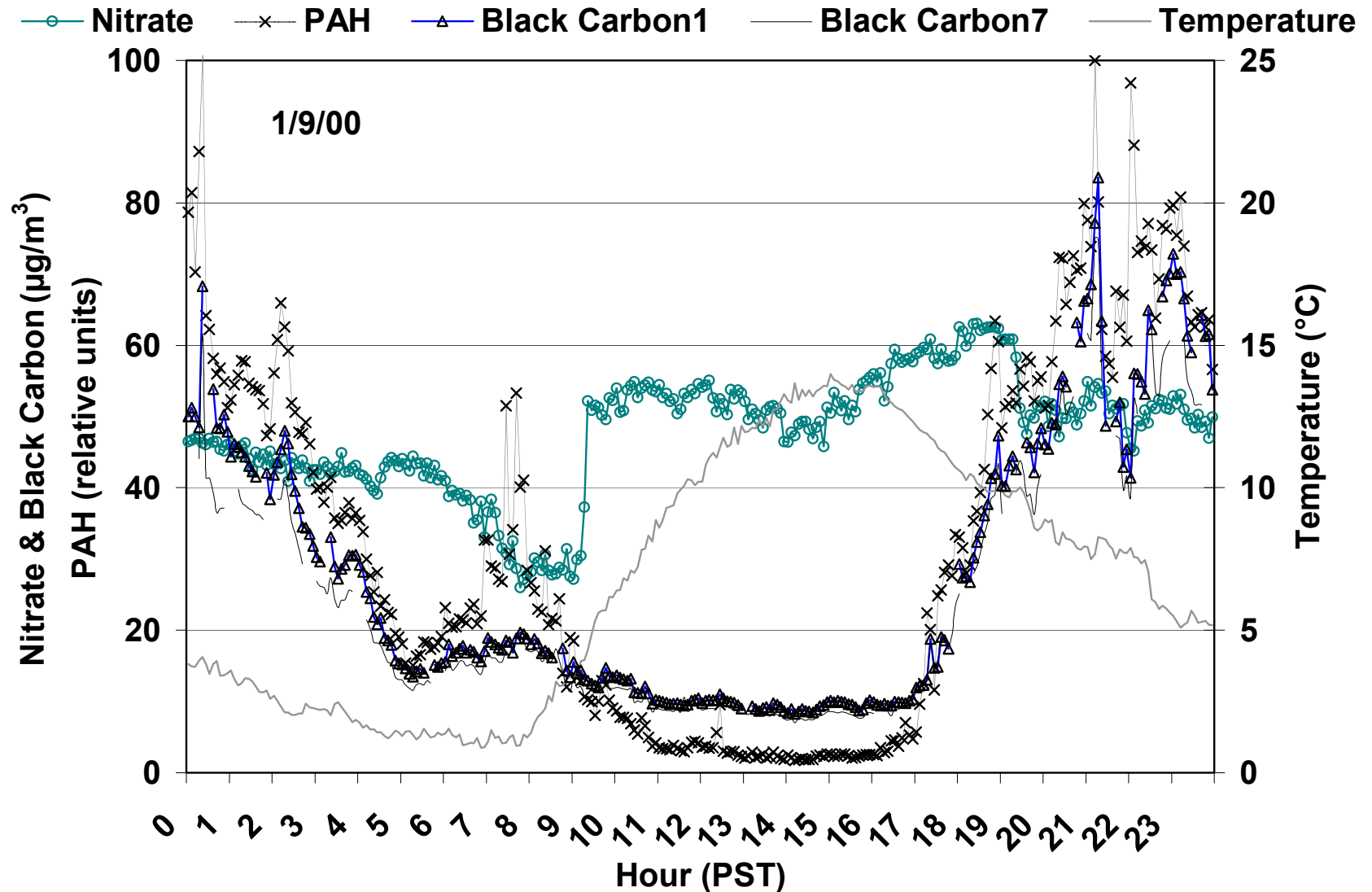
Advanced air quality measurement science

Fast time response instruments

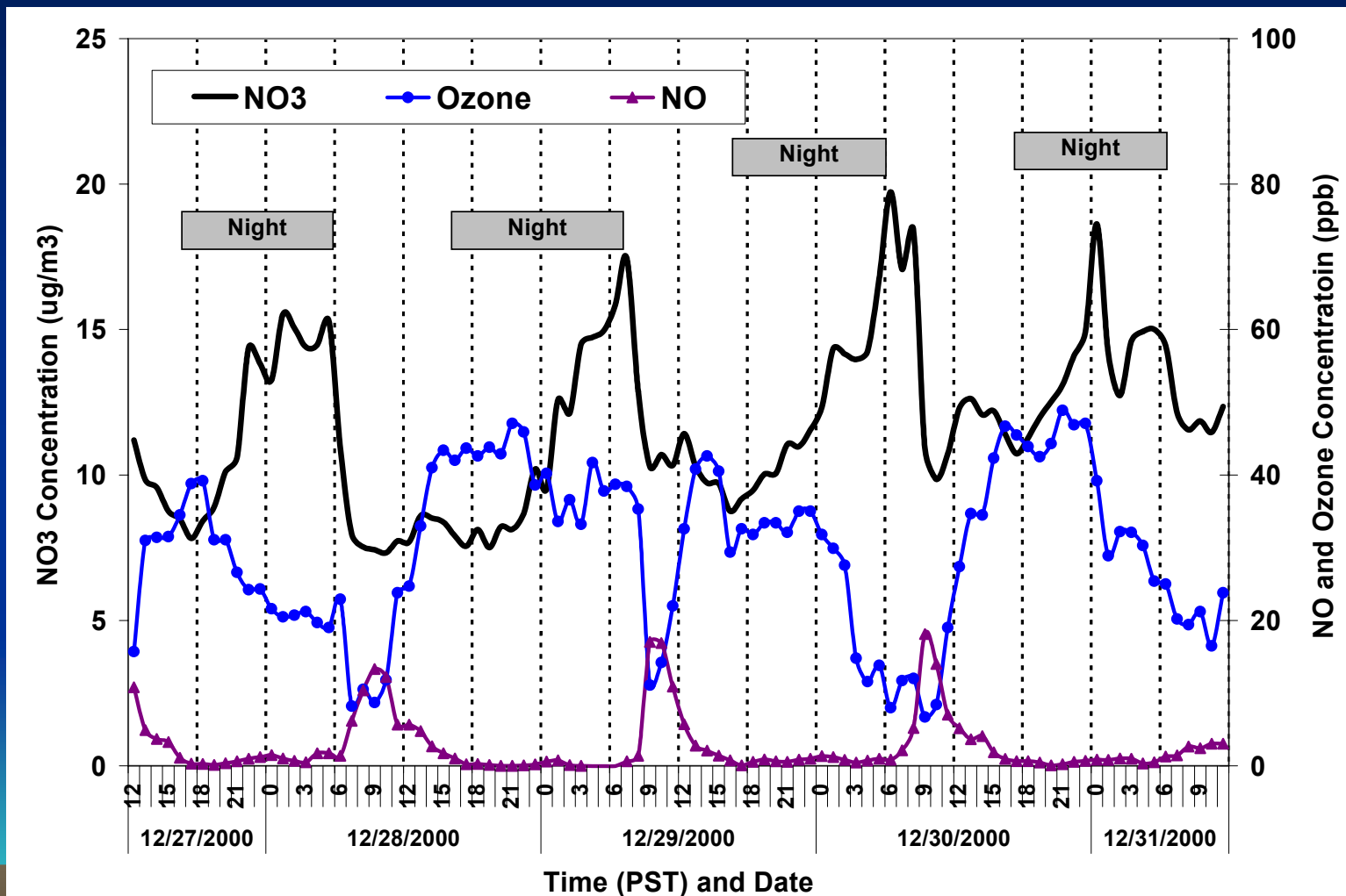


CRPAQS Findings

Observed vertical exchange soon after sunrise at Fresno



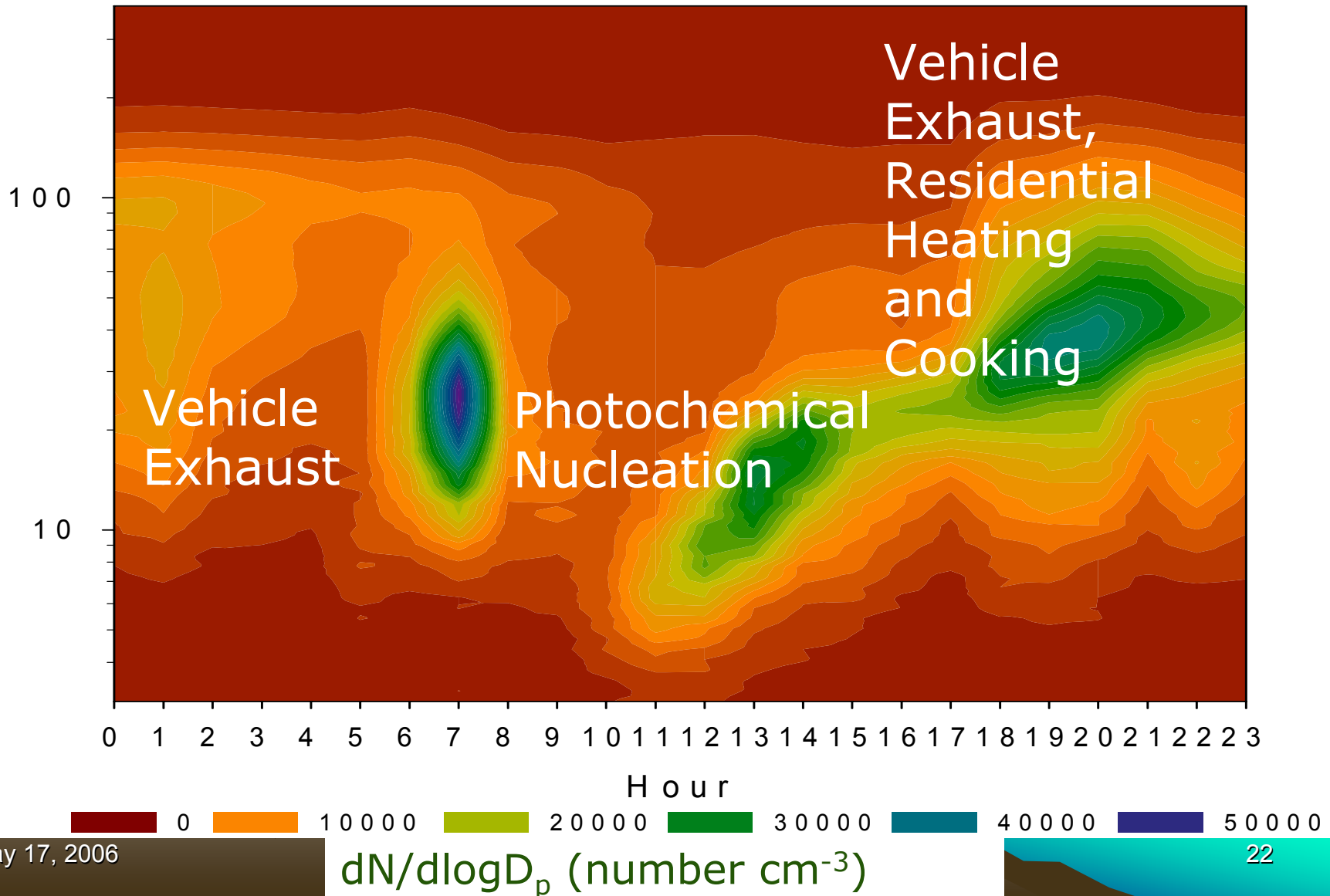
Verified formation and accumulation aloft with Angiola tower



CRPAQS Findings

Ultrafine particles come from primary emitters and form in the atmosphere

Particle Diameter (nm)



May 17, 2006

Other CRPAQS Scientific Findings

- Nitrate formation not limited by ammonia
- Sluggish surface winds do not preclude transport throughout valley at night
- No single cause of high PM_{2.5} levels. All emitters must participate in control strategies
- Often wintertime offshore flow from SJV toward Bay area
- PM removal by fog exceeds PM formation by fog
- More to come

Is this the last Central California Air Quality Study?

- What are effects of changing meteorology and climate on $\text{PM}_{2.5}$ and O_3 ?
- How important are off-cycle and high emitting engines?
- What is the influence of ships, trains, and other goods transport?
- How much is contributed by transport across the Pacific Ocean?
- How well did our pollution control measures work?
- Go back to step 1